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LESSONS LEARNED IN THE DEVELOPMENT OF THE C-130 AIRCREW TRAINING SYSTEM: A SUMMARY OF AIR FORCE ON-SITE EXPERIENCE

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The Public Affairs Office has reviewed this paper, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

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The current trend within the Air Force is to design aircrew training programs as *total integrated systems*. This trend has been coupled with a concurrent shift to contracting out the design, delivery and support of aircrew training. These changes have introduced a new set of technical and management issues which impact the design, acquisition, and operation of aircrew training programs. The Aircrew Training Research Division of the Armstrong Laboratory is conducting research and development (R&D) to address several of these issues in order to provide principles, procedures, and user-oriented guidelines to support Air Force acquisition and operational training agencies.

This paper is one of a series concerned with the identification of "lessons learned" by contractor and government personnel directly involved in the acquisition and utilization of contracted aircrew training systems (ATSs). It documents some of the major experiences and "lessons learned" by Lt Col Ron Dukes of the Military Airlift Command during his long involvement with the C-130 ATS program. The report provides a general description of the C-130 ATS program and summarizes Lt Col Dukes' experiences and "lessons learned" in the areas of courseware, training management, test and evaluation, quality assurance, and configuration management.

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TABLE OF CONTENTS

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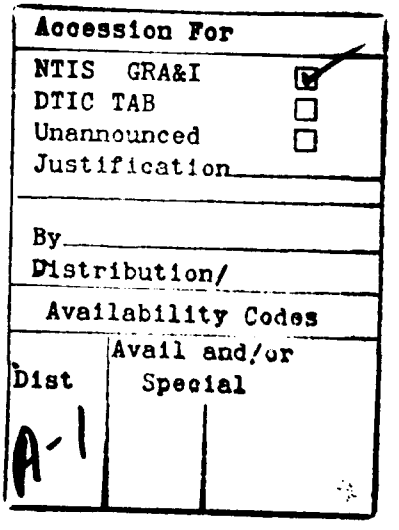
PREFACE

This paper summarizes the results of an intensive discussion with Lt Col Ron Dukes, Chief of the HQ MAC C-130 ATS on-site liaison group (MACOS OL Q) at Little Rock AFB, AR. The purpose of the discussion was to document the experiences and "lessons learned" by Lt Col Dukes during the development and implementation of the C-130 ATS. This information was collected as part of an ongoing effort to develop a training systems "lessons learned" database. The database is one element of a larger program concerned with the development of principles and guidelines for the design, development, implementation, evaluation, and operation of total aircrew training systems which is being supported by the Aircrew Training Research Division of the Armstrong Laboratory under Contract F33615-90-C-0005 with the University of Dayton Research Institute.



SUMMARY

This paper documents the results of a meeting with Lt Col Ron Dukes, the chief of the HQ MAC operating location (MACOS OL Q) with the C-130 ATS program at Little Rock AFB, AR. The purpose of the meeting, which was recorded on audiotape, was to document some of Lt Col Dukes' key experiences and "lessons learned" during development of the C-130 ATS. The information in this paper is an edited transcription of Lt Col Dukes' remarks. Thus, it should be noted that, although written in the first person, much of the content is actually paraphrased. During the course of the meeting, Lt Col Dukes discussed his experiences and "lessons learned" in a number of functional areas of the C-130 ATS program including: courseware, training management, test and evaluation, quality assurance, and configuration management. He concluded his presentation with a number of generic lessons learned which provide a profitable source of guidance for all military organizations involved in the acquisition of contractor developed and operated training systems.

LESSONS LEARNED IN THE DEVELOPMENT OF THE C-130 AIRCREW TRAINING SYSTEM: A SUMMARY OF AIR FORCE ON-SITE EXPERIENCE

I. INTRODUCTION

This paper documents the results of a meeting with Lt Col Ron Dukes, the former chief of the Headquarters Military Airlift Command Operating Location (HQ MAC MACOS OL Q) with the C-130 Aircrew Training System (ATS) program at Little Rock AFB, AR. The purpose of the meeting, which was recorded on audiotape, was to document some of Lt Col Dukes' extensive experience and "lessons learned" during development and implementation of the C-130 ATS. This information was collected as part of an effort to develop a training systems "lessons learned" database. The database is part of a larger program concerned with the development of principles and guidelines for the design, development, implementation, evaluation, and operation of total aircrew training systems which is being supported by the University of Dayton Research Institute under a contract with Aircrew Training Research Division of the Armstrong Laboratory (Rockway & Nullmeyer, 1990).

Background

The current trend within the Air Force is to design aircrew training programs as total integrated systems rather than as collections of courses or blocks of instruction. This trend has been coupled with a concurrent shift to contracting out the design, delivery and support of aircrew training (Grossman, 1989). These changes have introduced a new set of technical and management issues which impact the design, development, implementation, evaluation, and operation of aircrew training programs. The Aircrew Training Research Division of the Armstrong Laboratory is conducting R&D to address several of these issues in order to provide principles, procedures, and user-oriented guidelines to support Air Force acquisition and operational training agencies.

Currently, a number of Air Force aircrew training programs are being developed and/or operated with some measure of contractor support. For example, one of the major new initiatives is the C-130 ATS which is currently being developed for the Military Airlift Command (MAC) at Little Rock AFB, AR, under a contract with the CAE-Link Corporation. In addition to the C-130 ATS, each of the Air Force using commands is also planning, developing, and/or operating a number of other contractor-supported aircrew training programs such as the E-3A, F-15, and F-16 (Tactical Air Command); KC-10 (Strategic Air Command); C-5, C-141, C-17, and Special Operations Forces (SOF) ATS (MAC).

Because of the relative newness of the ATS concept, Air Force experience with respect to the acquisition and management of contractor-supported total aircrew training systems is extremely limited. Most of the Air Force's major ATS programs are still in

the very early stages of the system life cycle. As a consequence, there is relatively little empirical and/or experiential information to provide guidance for the design, development, evaluation, and operation of new or proposed systems. In fact, in most of the systems reviewed to date, major command program managers began at ground zero and were "learning by doing," except for occasional consultation with personnel in other programs which have only slightly more experience than they themselves have. Thus, there is a critical need to systematically collect, document, and disseminate experientially based "lessons learned" to training system acquisition offices and operational training organizations to ensure a more cost-effective approach in the design, development, and utilization of both ongoing and future aircrew training systems. Because of the number of aircrew training systems at various stages of development at the present time, a window of opportunity is available for initiating a study of lessons learned during various phases of the training system life cycle.

In response to the need for empirical data, Armstrong Laboratory established a program to develop an aircrew training system design/ "lessons learned" database. This database is intended for use as an R&D resource and as a source of information for the development of user-oriented guidelines for the cost-effective design, development, implementation, and utilization of integrated aircrew training systems. The objectives of this program are:

(1) To collect "lessons learned" by Air Force and contractor personnel in selected Air Force ATS programs and,

(2) To identify and document key issues/problem areas which might provide a focus for the development of a high payoff R&D program.

The bulk of the data obtained to date under this research program has been collected from several major Air Force ATSs that are serving as a core group for the identification of "lessons learned" and other kinds of training system information. Some data have also been obtained from other selected programs in both the Air Force and the other services. A series of visits have been made to several ATS contractor and military facilities to interview key program personnel. In addition, considerable time has been devoted to the review of program documentation and other relevant published information. As a result of these efforts, a number of major ATS issues/"lessons learned," which appeared to be common across several systems, have been identified. Some of the findings to date are documented and discussed in Rockway and Nullmeyer (in press), with special emphasis on the data obtained from the C-130, C-5, and KC-10 ATS programs. These particular programs are part of the core group selected for continuing review and analysis.

Purpose of This Paper

The purpose of this paper is to capture some of the more salient experiences and "lessons learned" by Lt Col Dukes during his long involvement with the C-130 ATS program. Lt Col Dukes has been personally and continuously involved with the C-130 ATS from the conceptual vision of the C-130 MATS (Model Aircrew Training System) study to the reality of its operational implementation. The coauthors regard Lt Col Dukes as a particularly valuable information source, not only because of his extensive experience with the C-130 ATS, but also because of his detailed knowledge of other contractor-supported training systems. Thus, in the opinion of the coauthors, he is uniquely qualified to provide a particularly valuable operational perspective with respect to the key issues and "lessons learned" in the C-130 ATS program. The information provided by Lt Col Dukes is being documented in this form in order to make it readily available as a source of useful information for personnel interested in the acquisition, development, implementation, operation, or R&D on contractor-supported training systems.

This paper is divided into five sections. Section I, Introduction, describes the purpose of this paper and the larger effort of which it is a part. Section II, C-130 ATS Lessons Learned, provides a general description of the C-130 ATS program and summarizes Lt Col Dukes' experiences and "lessons learned." It should be noted that most of the information in Section II of this paper is an edited transcript of Lt Col Dukes' remarks which were recorded on audiotape. Thus, although written in the first person, much of the content is actually paraphrased. During the course of the meeting, Lt Col Dukes discussed his experiences and "lessons learned" in a number of functional areas of the C-130 ATS program, including courseware, training management, test and evaluation, quality assurance, and configuration management. He concluded his presentation with a number of generic lessons learned which provide a profitable source of guidance for all military organizations involved in the acquisition of contractor developed and operated training systems. Section III consists of some brief concluding remarks by the editors. Section IV contains a list of references from the body of this paper. Section V contains a larger bibliography of reports which can provide useful information for personnel interested in the design, development, and evaluation of ATSs.

II. C-130 ATS LESSONS LEARNED

(Note: Except for the material entitled "C-130 System Description" under Subsection System Overview, this entire section consists of an edited version of Lt Col Dukes' remarks.)

System Overview

C-130 ATS System Description

The C-130 ATS is an integrated contractor-supported training system which is being developed under a contract with CAE-Link to provide ground-based training for all C-130 aircrew positions and engine run maintenance personnel. The C-130 ATS contract includes 28 courses for the Department of Defense (DoD) formal school at Little Rock AFB, AR, and all C-130E and H model continuation training. The system includes the optimized use of existing training assets, including ten C-130 weapon system trainers (WSTs), two cockpit procedure trainers (CPTs), and several part-task trainers (PTTs) which were furnished to the contractor by the government as is. It also includes all maintenance and logistic support for the WSTs and other PTTs within the program. It includes total system management of all ground-based training using computerized management tools, all scheduling, and all training scenarios for the flying environment. It also includes a training continuum which begins with entry into the formal school and ends with either transfer out of the weapon system or retirement.

Under the C-130 ATS concept, the contractor is responsible for the entire Instructional System Development (ISD) process from beginning to end, including formative, summative, and operational evaluations. The contractor is responsible for the development and production of all courseware, all ground instruction, all hardware modifications, and any new software development. They also are responsible for the total operation, maintenance, and support of the ground-based training system, all student management, administration, configuration management, and quality assurance. The primary product or output of the C-130 ATS is a "guaranteed student."

Guaranteed Student

One of the most important and least understood requirements of contracted ATSs is the "guaranteed student." The most prevalent assumption appears to be that the contractor's primary obligation is to ensure that students are able to pass an Air Force-administered flight check following contractor-administered ground training. This assumption is not entirely accurate. We have to educate both contractor and government personnel that the check ride is too small a sample of the aircrew knowledge and skills required to be used as the guarantee for an entire training course. The contractor has to be accountable for training all of the course objectives to whatever standard the government has agreed. In turn, the government needs a system to ensure that students have been properly trained on all objectives, down to the knowledge level in academics.

This is startling news to some contractors who have not completely thought the issue through. They do not understand the magnitude of the testing and performance tracking required. For example, the C-130 flight engineer course alone has 484 objectives, and that is just one of over 20 courses in the C-130 ATS. Generally, I point out the need to provide some kind of report to the government to document that all of the training objectives have been met. I further note that with any volume at all they will need to automate the process to make it both manageable and timely. This is necessary so they can prove to the government that all students have met the criteria for all of the training objectives prior to being recommended for a check ride. Until that is done, the student should not be put up for a check ride because the government does not know what was actually trained and what was not. This is essential because the government is no longer actively involved in that part of the training process under the contractor's control.

I also think that a lot of people do not understand that a large percentage of the critical things one needs to know as a crew member are not trained or tested in the airplane. For example, such things as electrical malfunctions, hydraulic malfunctions, engine fires, ditchings, etc. You may use the aircraft for practicing an engine-out approach or a windmill taxi-start, but that's about it for malfunctions. The other things are usually signed off to the required standard in the simulator and not on an aircraft check ride.

Guaranteed Training System

In addition to guaranteeing the capabilities of the student graduates, the training "factory" itself must be guaranteed. This concept did not seem to be a consideration in some of the earlier ATSs. No one in the military appeared to care about the factory, since they felt that was the contractor's problem. But if the military has to recompete the system and another contractor takes over, it is crucial that both the new contractor and the military know what they have. This really hit home for me when the Navy terminated their original contractor for the E-6 training program in Waco, Texas. The transition to a new contractor was made more difficult and more costly because no one had checked and validated through quality assurance, the factory. This will be discussed more when the importance of quality assurance and configuration control is discussed.

Courseware

Two major facets of courseware production in the C-130 ATS program will be covered. First, the development process used will be discussed, and secondly, our courseware production tracking system.

Courseware Development Process

To summarize the C-130 ATS courseware development process, most ATS contracts have similar requirements although the terminology used might be different. For example, some contracts call for master task listings. In our case, we have tasks and objectives documents. I believe that the TTTS (Tanker Transport Training System) has objectives and media standards or something like that. Whatever it is, you have to go through a similar process; that is, you have to start at the top and go through the objectives, select the media, lay out your courses, and prepare lesson specifications.

In the MSSR (Media Selection Syllabus Report), we list the units of a course and then for each unit we break out lessons as Lesson 1, Lesson 2, Lesson 3 and so on. For every lesson we list the objectives as Objective 1, Objective 2, etc. For each lesson we have no less than two and, in most cases, no more than ten objectives. We define the instruction/courseware for each of the objectives as a lesson segment. This system has worked well for us and was a big lesson learned out of C-5, KC-10, and B-1.

If I had to do it again, I would basically do it exactly the same. In some programs, a different approach was used. For instance, in one of the programs that I am familiar with, as soon as they identified objectives, they started writing lessons. The problem with this approach is that each objective is considered somewhat in isolation. For example, if an objective is performed on a Before Takeoff Checklist, do you put "notes," "warnings," and "cautions" in there, or in another lesson? In our case, we had an outline requirement as a contract deliverable. So on the first page of the lesson segment, you will see the objectives/segments and in the outline it will begin with Segment A. Before we start writing, we agree that this is the level of detail to which we are going to write the lesson. To save work for the contractor, there was a blanket statement on each one of the academic lessons which said, "If there are any 'notes,' 'warnings,' and 'cautions,' they will be covered in that segment. Also, if appropriate, you will also cover any switch, gauge, or light that is appropriate for that system."

In our initial cut at this, we went down to the individual switch level on the master task listing. We did that based on the approach used for the C-130 MATS (Model Aircrew Training System study). (Note: For further information on the MATS program, see Fishburne, Williams, Chatt, and Spears, 1987; and Fishburne, Spears, and Williams, 1987.) The MATS program identified 100,000 objectives. In the C-130 ATS, we ended up with about 14,000, and even that is a volume nightmare for the Training Management System (TMS), but 100,000 was totally unworkable. After considerable discussion we decided that we did not want to remediate to the switch level. We felt that if the student did not know how to

throw the right switch, this was probably an indication of a bigger problem. Therefore, you probably should be looking at the whole line on the checklist. Thus, if it was something on the Before Takeoff Checklist, you might simply say, "Set hydraulic panel, set fuel panel, set electrical panel, and so on." In some cases, there might be up to eleven steps on that one step where the student had to go across that panel and set switches. So at that point we said, "OK, we'll remediate him to cover the entire step and all the switches/procedures on that step."

However, after thinking about it some more, we realized that if a student has a problem with an individual step, he probably needs to review and practice the whole checklist. So we finally settled on the checklist level as the starting point. A singular checklist or a singular procedure became the norm for hands-on objectives. A singular procedure, whether it was an emergency procedure or a normal procedure, equals one objective. We remediate to the level of a single checklist, procedure or single air maneuver. With this approach you do not list things at the level of "perform landings." If it has an "s" on it, it is too high. It has to be "perform 100% flap landing, 50% flap landing, no flap landing, cross wind landing, engine out landing, and night landing." You spell out each one and each one has its own objective. The same applies to approaches. For example, you should not simply say, "Perform non-precision approaches." There are all kinds of approaches and they involve totally different procedures, so you have to be specific. Taking the singular approach really worked for us, and we agreed upon the level of detail in the lesson specification document before we started writing the lesson.

Another lesson learned, and something the C-17 guys did which I think is a waste of time and money is that they required the contractor to deliver all of the lesson specifications before they wrote the first lesson. Also, they wrote lesson specs for lessons that they were not going to start writing for another year and submitted them to the government. The airplane has not even been to OT&E (Operational Test and Evaluation) yet, so many of the lesson specs will be OBE'd (overtaken by events) and in my opinion require major rewrites. We originally had a similar requirement, but saw this as a possibility early on and with ASD (Aeronautical Systems Division) approval, we said, "You may not begin writing a lesson until a lesson specification has gone through an informal government SME (Subject Matter Expert) review and you have an SME signature on it. At that point in time, you can begin to write the lesson, but you won't have to deliver the lesson specification to the Government until thirty days before CRR (Course Readiness Review)." This allows final changes to the lessons to be reflected in the specs if required.

After a lesson is written, it almost always requires some modifications. For instance, you might research the regulations

and find that there is something in MACR 55-130, C-130 Tactical Airlift Operations, that should be considered, so you have to put it in. These are changes that both the government and contractor agreed needed to be done.

At the last step of the courseware review before CRR, we conducted what we called a "courseware configuration audit" which generally took about four hours to complete and another four hours for the TMS crosschecks. We took the MSSR, the lesson specification and the lessons themselves, and we matched all the objectives and the objective numbers along with the test question references, and made sure that the course guides and the unit maps all coordinated.

When you follow a process like this, it allows you to start with a nicely configured product. Then when you make changes, there is a line in the process which says, "Check the lesson specification to see if it is affected and check the MSSR."

The two top level documents, the task listing and the objectives hierarchy, will be done in conjunction with the last block of courses because they are not course specific. They cover the whole system. Prior to the last block CRR, we will take all of the MSSRs that are configured and check them against the objectives hierarchy and the task listing as part of the last block's review, and then we will have the whole system configured.

The formal school regulation (MACR 50-9, MAC Formal Aircrew Schools Management) requires us to do that same type of audit. So, in my view, the government in conjunction with the contractor should continue to do a similar annual audit to check the match. If you do not, you end up with a system that will slowly grow non-concurrent.

Our development process involves 55 steps. These 55 steps are divided into three phases. The end of Phase I is ITOs (Individual Try Outs), the first T&E (test and evaluation) test. The end of Phase II is an SGTO (Small Group Try-Outs), and the end of Phase III is the CCA (Course Configuration Audit), which is course work, configuration, and audit. In other words, this is the delivered baseline. Of course, it is not "<u>finally</u>" baselined until TSRR (Training System Readiness Review), but it was configured as an initial baseline at the end of the third Phase. My biggest lesson learned here is don't do ITOs. Instead, do UTOs (Unit-level Try-Outs). In my view, our ITOs gave us only two pieces of valid information--you got the reading level of the lesson and a ballpark time hack. But the reason I say do the test at the unit level is that we automatically waived all the unit tests and the unit reviews and the end of course exam because you know each student is just looking at one lesson at a time during ITOs. If you gave students a unit review, they would not know what you were talking about, since they hadn't seen the whole unit. So I recommend doing

try-outs at the unit level. In other words, get a new student that has not seen hydraulics yet and give him the whole hydraulic unit, and then give him the unit quiz and the unit test as a part of the UTO.

The biggest problem we had with ITOs and SGTOs was scheduling. We started out with 2,000 lessons, and ended up with about 1,867. Our planned schedules were all running over, especially CBT (computer-based training). However, if you run them at the unit level, you would get a better overall picture of time. The biggest write-up we had in SGTOs, and you probably could have predicted it, was that our unit reviews were less than desired. The contractor had gone back to the individual lessons and just reproduced material. A better idea is to conduct the review in a more abstract form and play with it a little bit, like you do in a good lecture. ISD's position was that you had to follow the format guide. Our major rewrites occurred in the unit reviews. That is a good lesson learned, I think. It makes it easier on both the contractor and the government to schedule the units as blocks and requires fewer students.

Quality Control. The point that I wish to make here is that the courseware quality control function (QC) is not the same as quality assurance (QA). QC is internal. In other words, that is someone looking to say, "OK, this is our style guide, these are our conventions for color," etc., and that is all QC is checking. They are doing a QC of the lesson in terms of format, spelling errors, does it read right and that sort of thing. In no way, shape or form is that quality assurance, because QA has different functional requirements. But I want to make that distinction here because you have QC in many different things. You can have QC in maintenance, like in your CLS (Contractor Logistic Support). You can have QC in your TMS (Training Management System). Guys checking what a guy programmed and that sort of thing, but that is quality control. Quality assurance and quality control on C-130 ATS are apples and oranges. One is internal, and the other is external. That is the key. QC is internal. When I get to the QA part of the discussion, I will spell out the differences more explicitly.

Government Review. There is a government review in each phase. In Step 8, Step 18 and Step 42 of our 55-step process, we had government reviews. One of the things that came up early--and we were saved by our CRR checklist--is, "What if you get to the last government review which should mean all the write-ups should be cleared and they're not cleared?" Early in the program, we would see as many as 50 open write-ups when the contractor was letting things ride. What we did after the second government review was to transfer them to a CRR open-action item checklist and state, "If you don't fix these by CRR, you don't pass." That is why the CRR checklist that we signed up to one year before the first CRR was so important. It meant that there was no argument. For example, our last CRR was 30 seconds. The one before that--we

did the long loadmaster and navigator course--was six minutes. If there is an open action item, everybody knows what it is before you go in the door. You just sit down and run through the script, sign it and leave. "It's really important to have that checklist." I have given copies of it to almost everybody. It will have to be tailored for each contractor to sign up to, but it is very comprehensive. An additional thought here is that initially in your first blocks, it is very tedious to do all the facilities and instructor CRR checklist items, but these will fall out in subsequent blocks because you have already checked them.

Courseware Production Tracking

Production tracking, or the lack of it, is what caused one of the biggest problems on this program. The contractor did not know where they were in terms of the courseware development schedule. We also did not know where they were, because we expected them to use a tracking system which we would manage against. However, since they did not have one, they did not know whether they were a month ahead or a month behind. At first, they were going to build their tracking system in the TMS, but that did not work out. Then they put wall boards up and down the halls. That lasted one week. And they pulled them down. They finally ended up with Timeline 3 which did a very good job. Through trial and error we established due dates and timelines on about how long it would take to do one of those 55 steps. Of course, the long parts are the authoring and the artwork. But some things, like simulator scenarios, might take three weeks to develop and a half day to test. We got our estimates massaged enough so that now it works fine and there are no problems.

To stay on track, the production information was all loaded in Timeline. They have three people full-time that work Timeline. They take a sheet of paper with all the lesson production steps on it and draw a black line out to the step that it was at. The personnel on the night shift would enter all of it into Timeline and update the schedule. Because we have had as many as 1000 lessons in production at one time, it was critical to get an automated system running.

This did not happen until about nine months into the program, and I would get a copy which said, "Here's where we're supposed to be and here's where we are." Initially, when there were still problems, I built a manual system to track their progress, so when things came over for government review, and they would say you are supposed to get 20, and I would get 2, I would say you are 18 short. The bow wave kept getting bigger. And every week I would raise the issue, and they would change the schedule. Anyway, what finally happened was that they implemented Timeline and put all the due dates in and tracked against those dates, and it worked fine.

With Timeline, we set up a three-day tracking window. With a three-day window, if the lesson got ahead by three days, you could actually slow it down and play catch-up with other lessons and do some tradeoffs, but if it got behind by three days, they put a red tag on it. When we have a stack of lessons to review, the first thing my men would do is look at the due date and prioritize it. If it has a red tag on it, it goes on the top of the heap, and that has worked very well.

We have told them the schedule is a stake in the ground. They cannot simply change the due dates. Initially, when we were just beginning, they had three days to author a simulator scenario, and the men over there were saying, "No way." Because it actually took weeks to write them, including such things as the malfunction codes, the scenarios, the weather, and the integration between crew members, it is not just a simple thing to put one together. My "lesson learned" in courseware tracking is that one should gather data to find out how long it takes to complete a job. Then use it as a basis for assessing whether or not what the contractor tells you is in the ballpark.

There is an upper limit with respect to the number of lessons in production that can be tracked manually. In my opinion, the break point is about 400 lessons, although this may change as a function of lesson complexity. Above that number, you need an automated system. When they started, Block 1 had 44 lessons and Block 2 add another 100. When we reached the instructor school in Block 3, the schedule hit the fan. We just lost it, and Block 4, the largest block, was unreal. We have had over 1000 lessons in production at one time, all somewhere between Step 1 and Step 55.

Many people do not understand that building lessons for a course is not like building simulators. If you are building 1,000 simulators, every little red wire that goes into this box is exactly the same for all simulators. On the other hand, there are no two sentences in any course that are the same; and no two people that review it will look at it the same. One of the biggest "lessons learned" was the need for a step to run a lesson by the instructors. We did this because, after they ran the first couple of courses, the instructors criticized the courseware saying, "We don't teach this way. It doesn't flow for me in the classroom." Of course, on the Air Force side, we were saying, "I told you so," because the contract would not let us comment on flow, only on content. However, when hundreds of ICPs (Instructional Change Proposals) were submitted on the lessons, they found out that it was costing them money. If they had done that instructor review in the first place, they would not have had to redo quite so much. So, getting a process and production tracking system in place that has been validated is really important if you are going to make a schedule, and make it within budget.

I think that our estimates of courseware development times have some generality for other systems. The only ones that might change significantly would be CBT. This is particularly the case if you add in IVD (Interactive Video Disk), which we did not have! If you have IVD and do a large amount of branching, the development time will go exponentially out of sight. When we started out, it took about 468 hours to develop a CBT lesson. However, by the time the graphics library was built and the packaging teams were humming, where they knew the key strokes and how to really move, we were down to about 320 or 328 hours per lesson. It seems that these averages hold up no matter how complex the lesson. So that was a good "lesson learned."

Training Management System

The C-130 ATS TMS consists of eight modules:

1. Administrative management
2. Resource management
3. Curriculum management
4. Scheduling management
5. Performance measurement
6. Reports
7. Configuration management
8. Logistics management

The biggest lesson learned in the TMS was that we and the contractor underscoped the required system capacity, because we underestimated the amount of data involved in building an integrated system. When we started out, we were going to do the whole thing on two hard drives, with 800 megabytes each running on two AT&T 3B2600s. We now use five at the formal school. The curriculum module itself now requires two to handle all the courseware and CBT information.

As noted previously, we have one integrated TMS database that handles the bulk of the instructional system functions. In my view, some of the other ATSs that did not follow this approach are in for some tough times in the future. For example, in the C-17 they are writing the courseware on an AIS II, and their TMS is part of the CMI (Computer-Managed Instruction) on that system. They will probably not have the capacity, speed and flexibility that we have with a single integrated relational database. The big advantage of the way we have done it is that all of the modules can talk to each other, since everything is in one TMS relational database. I'll cover each of the TMS modules in turn.

Administrative Management Module

The administrative management module does three basic things: (1) It runs the registrar function, (2) it handles all of the security requirements, and (3) it transfers data between the sites.

For example, when a student graduates, the administrative management module sends the students' files over a modem to the gaining unit. So, it keeps track of the crew force in terms of their records. We will also handle the historical documents through this module, although that has not yet been implemented. We are handling the essential files first. We also have to make some decisions about what we will keep on-line and what will be downloaded and archived on tape.

Resource Management Module

The resource management module is where you store information about the system resources. For instance, it might store Marty Rockway as an instructor. It also stores what he has been trained to teach; e.g., perhaps he can teach in the classroom, but he has not been checked out on the simulator. On the other hand, Bob Nullmeyer can go to the flight line and teach anything that he is certified to instruct. If you try to log him into a class as an instructor for a particular lesson and he has not been certified for that lesson, the module will not let you schedule him. It keeps track of all of the instructors and what they are qualified to teach. It also keeps track of all facilities, such as classrooms and briefing rooms, so that if one is being used it cannot be double-booked. It does all of the checks and balances there.

Early on, we had a tendency to forget that the simulator briefing rooms were used for both prebriefs and postbriefs. Because we run extensive prebriefs and postbriefs, overlap problems may occur if timing is not watched closely. However, with proper scheduling, one crew should be prebriefing while another crew is still in the simulator. Other things that the module tracks are all of the hardware, including all aircrew training devices. The module also stores the CBT terminals and knows how many people can get in there and at what time. It also keeps track of the learning center.

The other thing that the module does--and this is a "lesson learned"--is store the configuration of all training devices. This would be important, for example, if we did a SCNS (Self-Contained Navigation System) modification to one of our simulators. Then, if a student went through a nonSCNS courseware, you could not put him in a SCNS box. Thus, it would not let you schedule against a box that was in a configuration that did not meet the curriculum.

Curriculum Management Module

The curriculum management module is one of the biggest modules we have. It contains all of the master task listings, objective hierarchies, MSSRs, lesson specifications, lesson materials, etc. It also has CBT information. We write up through the story-board phase on the TMS. For configuration management you need only to

configure off your storybook documentation, because that is where you have logged the frame numbers, text segments and so forth. When configuration management interfaces is discussed later, you will see how this all ties together. It is really slick. With over 1,800 lessons to manage, that is why there is so much in the curriculum.

In curriculum management, when we do the MSSR unit listing, the complete flow of the course is given, and that is where we actually initiate the student's schedule. The scheduling model interfaces and pulls it off, but you may have to add in a few things each time, however, like lunch. I think I told you before that we forgot to include lunch on the first two days that we ran SGTOs. It didn't take long for the student to let us know we had a problem.

Also, another big "lesson learned" is that the computer does not know whether you are at 12:00 a.m. or p.m. until 12:01. This is because it runs a 24-hour clock against each day; 12:01 is a whole new day. If a student is going to the simulator and he gets out at midnight, the computer might schedule him for a CBT lesson an hour later. We had to artificially install crew rest requirements and bed rest so a student could not be scheduled until 8:00 or 10:00 the next morning. The computer knows that you are done with Tuesday and now you are up for Wednesday, so you have to put that in.

Now, let me explain to you how the system works day-to-day. Marty Rockway logs into the school. When he logs into the school, he will fill out a card, and it says, "I'm here to take the CIQ (Copilot Initial Qualification) course, Class 8806." The system automatically checks that his flight physical is current and he has been through the physiological training and has all the prerequisites to cover the course. If not, it raises a flag and we try to work that out. After he is inprocessed, the night shift enters all of the data into the computer. The next day when he returns, he receives his class schedule. Then, the administrative management module goes down to the curriculum management module and retrieves all of the objectives in the course for which Marty signed up. It lists them in the order of the MSSR, starting with academics, and inserts every single objective against his name. Then, it is the performance measurement module's job to log them off and keep track of when Marty's ready for his check ride.

Scheduling Management Module

The next interface is the scheduling management module (SMM). The scheduling management module retrieves only the information it needs from the other modules, such as the curriculum management module and the resource management module, in order to accomplish its task. After you have been logged into the system, the SMM takes over. It is run by the schedulers (there are three full-time

schedulers) and they begin with the baseline curriculum. The whole curriculum is on the screen, and there is a little asterisk/cursor you move down and then key in all of the lessons you want to schedule. We then print out a two-week schedule, because one any longer than that would have to be changed because of remediation. You get a two-week schedule on day one and will know what you will be doing every hour for the next two weeks. It will list your lesson, classroom number, etc. It will also give you the instructor's name. When required, you will receive a new, revised schedule. If you enter remediation, the SMM will update your schedule and project it out. If you have real problems, washback, sickness, etc., your schedule will be adjusted to produce some fillers. Right now the scheduling management module will produce an individual student schedule as well as a schedule for instructors. This means that if I am an instructor, it will give me exactly what I will be doing for the next two weeks, where and when to report, what lesson I teach, so I can plan for it.

We are still managing the basic formal school by blocks or class of students. There is some capability for individualized management and some capability to test-out of parts of a course. Because of the volume of students and facilities limitations, we are relegated to managing students in class blocks. However, there are some self-paced areas like CBT where if you complete a lesson, you can get ahead, leave, or come back at night to do some more. As you know, different people work at different rates and CBT allows for that. In fact, the CBT facility is open until 10 p.m. for this reason. However, CBT is the only area in which you can leave and go to the BX, then come back that night and do the lesson. The only requirement is that you finish it before the next lesson for which it is a prerequisite. This is because the system will not let you log on to a lesson for which you have not met the prerequisites.

The SMM still does not print out a standard daily flight schedule. Such a schedule would show, for example, that Dukes and Bob and Marty are going to Jackson, Mississippi, they have an 8:00 takeoff, the fuel is 36,000, the load is X pounds, and so forth. The data to do this are all in the system, but the TMS does not currently have a program to bring it together and print it out line-by-line on a daily schedule basis. They are working on this now, and the daily flying schedule is due out later this year. We have been running a test at Dyess AFB on our squadron scheduling which to date has been going well.

There is a possible interruption brewing in this area at MAC Headquarters. The DOO (Operations Center) staff has briefed the new CASS (Computer Assisted Squadron Scheduling) software to the DO (Deputy Commander for Operations) and it is supposed to hook up to the numbered Air Force and MAC scheduling that goes all the way up to the Air Staff. The DO point of contact said in both cases the interfaces work, and he thinks that CASS is slightly ahead of where

we are because we just finished CDR (Critical Design Review) last week and are not yet into the detail of working AFORMS (Air Force Operations Resource Management System). I think we have defined the requirement; we just have not accomplished any programming. The CASS idea is valid if you are trying to standardize the command; in other words, the C-5 guys, the 141 guys and everybody that interfaced with MAC will hook up because it is written in a standard language. The latest word that I am getting is if we go to CASS, we would terminate C-130 ATS squadron scheduling.

Performance Measurement Module

The performance measurement module (PMM) in my view is the most critical module in the ATS and one that has been designed and built from the ground up. It is the module that checks to make sure the student is signed off against all of the objectives--from academics, through all of the hands-on training right up through the check ride. We have a bubble sheet that gives us feedback that is tied to the objectives. The volume is at a point now that it is starting to give us feedback to do overall curriculum assessments and refinements.

Currently, the PMM is handling mainly student data, but we are starting to get some system level performance data out of it as well. We have created some system level performance trend graphs as part of summative evaluation. One covers check ride results, Q1s, Q2s, and Q3s. We are also trending late graduates and student deficiency reports, i.e., things above the level of the individual. We are still growing in this area. Next month, all of these T&E automated reports are due.

The student training report is generated out of the performance management module. When a student first logs in, if you pull his report it will show all of the objectives in the course against his name. As the student progresses through the course, the entry for "objectives not trained," will start reducing. There is another section that lists all of his academic scores on his unit tests and end of course exam. If a student does not meet criteria on a hands-on objective and requires more training, that will be on the record also, and it will show where he is weak. If the student does meet criteria on time or falls below criteria at a later date, that also will be on the record. Additionally, any objective that is remediated becomes a part of the record.

We pull the student training report when the Air Force flight instructor comes down from the flight line to observe a student in the simulator before he goes to the aircraft. This is particularly critical for new pilots, since the Air Force instructor no longer trains his students in both the simulator and the aircraft. Thus, the simulator observation provides the instructor with a preview of the student's capabilities prior to the first aircraft training

sortie, and the report provides this overall view of his simulator performance. In fact, we will probably end up with initial qualification course pilots being observed twice by their Air Force flight instructors in the simulator before they go to the aircraft. The other crew positions and other pilot courses will probably be observed only once or, in some cases, not be observed prior to their first aircraft sortie because there are fewer safety concerns.

Since new initial qualification pilots have the stick in the aircraft, it is important that the instructor has the opportunity to see whether he is really comfortable with the student's skill in the simulator before they go out to fly. For some of the other positions, e.g., loadmaster, such observation prior to the first flight is not as crucial since the instructor will be standing right alongside the student in the aircraft. In any case, we pull the report when the flight instructor meets the student, so the instructor can check on how the student has performed in academics and hands-on.

The next time the student training report is pulled is just before the student is recommended for the check ride. Incidentally, this is mandatory, so we have written some QA procedures to check it. Thus, if I were a student, and it is time for my last aircraft flight before the check ride, the flight instructor would pull my report. The only things that should be open on the report at this point are those events that the instructor plans to cover and sign off that day. If there is anything else open, such as some landing condition that needs to be tested in an aircrew training device (ATD), we inform the contractor. We also check the grade folder to see if it is just an entry error or if the student really needs to go back for training. If training is required, the contractor must provide it before a check ride is authorized. We now have a procedure where the contractor's instructor operations office pulls those checks, comparing the data in the grade folders with that in the TMS for discrepancies. If the student has a clean sheet, i.e., no objectives untrained, no objectives not tested, then in my opinion that is when the student guarantee is fulfilled!

Let me discuss one of the things we have already pulled out of our T&E data. We went back one year and determined the average percentage of check ride failures for the last year. If the C-130 ATS meets or does better, then we know that the course has met the TSRR criteria. It turns out that in the basic navigator course, 30% of the students received Q2s. Looking deeper, we found that was not as bad as it looked. The reason for the deficient rating was usually a pacing timing error with the SNS (Satellite Navigation Station). In thirty minutes they are signed off and out the gate, and now it is the contractor's responsibility to sign that off. These are some of the goals we are trying to achieve in this new management system.

Many people do not fully understand the importance of the PMM. This goes back to our previous discussion about the meaning of the student guarantee. This is where you must verify the guarantee. You always have a backup, of course. You can always pull the student grade folders and get the information that way. But this is not feasible when you have 400 students on site, on any given day, and the government does not have visibility into three-fourths of the course. This seems to suggest that the government needs something that is much more efficient than a labor-intensive manual system in order to know what is going on. The PMM gives you an on-line tool for tracking student performance and generating relevant reports in practically real time.

Additionally, we have regular QA checks on the system to eliminate pencil whipping. We pull the training folder and compare it to the computer-generated report to see if they match. If there is a mismatch, we write them up. We have caught a few discrepancies. In fact, we have a process now where each and every grade folder is checked after graduation.

Reports Module

There are 18 reports on the CRR checklist that are due at different times. All but two of them are formal school reports that we have always generated. The data for these reports now come out of the TMS or out of the contractor's registrar function. The most significant report, and the one on which we have worked the hardest through PDRs (Preliminary Design Reviews) and CDRs (Critical Design Reviews), is the student training report.

Before CRR, we accomplish our final configuration of courseware and sign off all of the lessons. During this process, we match everything. We take the MSSR, unit tests, and end-of-course exams and compare them with the student training report and run it two or three different ways. First of all, we run it with no objectives accomplished and make certain that every single objective on the student report matches what is in the actual course. They are required to match right down the line. The next thing we do is take the unit tests and check the numbers to make sure they are identical to their respective objectives. The next check that we pull, which is very important, is to look at the tests, the bubble sheets, and the student training report to ensure they match.

The process that takes place in the system is as follows. The student takes the test and fills out a bubble sheet. The bubble sheet goes into an optical scanner where it is read and fed into the PMM and graded. From the PMM, software then generates the training report. In our configuration audit, we check the whole thing from A-Z. Basically, we are checking to see what is marked on the bubble sheet and if the bubble sheet is, in fact, the right

answer, and what we've already configured at our courseware configuration audit is absolutely correct.

We have found a few problems on how the machine graded the student. I mean the student training report said he got it right when he really got it wrong and it is a data entry problem. Most of this is because the last thing we change is the courseware, and then you have to change the appropriate test question, and they did not get the same data changed in the TMS. This is generally because we pull this check at the last, and we pull it off the live database.

One of the important things you will want to make a note of is the question, "Who is responsible for all of the data the TMS gets?" Is it the software guys since they are writing all of the software and entering it, or is it ISD because all of the configured documents equal the data? Now, how do you get the data into the TMS? Some of it is transferred straight across, but a lot of it, like test questions, etc., are actually keyed in because it has to match the software hooks at the right time and place. Also, who is responsible for the correctness of the data? ISD's position was, "When I get to configuration, I'm done." TMS said, "Not me, I'm just software. I just make sure the software runs properly." Anyway, it ended up landing in ISD because it has to pass the hard copy checks. They have two people full time, to keep all of the TMS data current. They are part of the courseware configuration team.

When I try to explain this to software people, it goes over their heads. They do not understand that when you are making a change to courseware, you may have to change something in the TMS data base. You have to track the data, and there are people assigned to do just that. Anyway, to reiterate, the most important report that we receive is the student training report, and it must be checked very, very carefully. Sometimes when you get these long courses, you are checking 484 objectives. It takes hours, but you have to do it.

Configuration Management Module

In every other system that I visited, the configuration management function was external, but in the C-130 program it is internal. I can walk in to the contractor's office and punch courseware information in right there and configure it. When you realize courseware is about 90% of our effort, the timesaving is enormous.

When we do a design request and assign a number, we go right into the lesson plan configuration. We pull out the lesson specification which identifies all of the lesson segments, frame references, graphics and all the other data you might need to look at that might need to be changed.

Since it is internal, it helps you search out what you need faster, including CBT. For CBT, you still have to go to a CBT terminal to find the actual material, but it tells you where to look. You can code it in a variety of different ways, and there are different ways of sorting and checking, but the key is it is all internal.

We use the Informix Relational Database, and it contains data right down to the detailed tables so information can be tracked very easily. All this detail is just beautiful from a management point of view. You can see what we are training, where we are going, and where the gaps are.

Logistics Management Module

The last module, logistics management, does not have to interface with the other modules. It is strictly an off-the-shelf system that runs your maintenance, logistics, shipping and receiving for the depot and the sites. It also tracks the backlog of work orders at the depot and all of the sites. It tracks all of the AWMs (awaiting maintenance) on a daily basis so you do not get behind. It tracks your "awaiting parts," so you know if you have a parts problems and supply problems, etc. The information is provided on management charts with bar codes so you can see month-to-month whether we are getting better, i.e., this many work orders open, this many closed, this many backlogged. If the backlog is getting bigger, then you know you have problems to work through.

Test and Evaluation

Without T&E, in my view, neither the contractor nor the government know where they are functionally. They would not have good data to make sound decisions about where they are, where they are going, what they need, and how well the system is working. It is not so much a T&E job to say, "Is something in compliance with the contract?" That is more of a QA function. The more important issue is--Does it work? Is it operational? Is it functional? You can build an ATS that is totally "in compliance" with the specification which does not work at all. "I know you can do that." We have come close here a couple of times with aircraft schedules and operational input that we just did not consider. So T&E in my view is absolutely mandatory. Of course, our big lesson learned is that we did not start our T&E program early enough. We are doing some things early in the summative evaluation phase that we should have been doing in formative evaluation. It took us nine months to a year to get the T&E program on line, and the contractor is paying the price now.

A good system level formative evaluation--"system" is the key word here--would have really let us fix many things early, instead of coming back after SGTOs and having a lot of write-ups. This is tremendously important if the command is to have an ATS that works

the first time. This is a critical point. The traditional T&E concept is that the government can allow the contractor to fail. "You have to give him enough rope to hang himself." In ATSs, you cannot do that. You cannot stand the ATS in the corner and say, "Well, we won't use the simulator, we'll do it in the airplane; or we won't use the CBT, we'll do it in the lecture." ATSs do not work that way. They are services contracts, they are not hardware, and a hardware contractual mentality will kill you. It has to work the first time out of the chute. My job is to ensure that we graduate a student that meets all the minimum requirements. You have to answer the question, "Can he do the job coming out of the chute the first time?" You then have eight months of summative evaluation to tweak the course and really put out a refined product.

We cannot afford to let the contractor fail. Why? Because our resources are gone. Our expertise is gone to the contractor. He can hire our blue-suit people, but it will take an act of Congress to get that guy back in the service and put him back into the blue suit. To put another blue-suit schoolhouse together would take two or three years minimum, in my view. So T&E is not a subject that should be taken lightly. This contractor will be the first to admit that they did not realize the value of it. Now their management decisions are all made on the basis of T&E information. In the past they would say, "We just don't have enough guys to go around for T&E." Now they have hard data from T&E to pinpoint where and how effectively their resources are being used.

Our basic T&E master plan covers the formative, summative, and operational evaluations and the relationships among them. It identifies the scheduled start and end points, and the kinds of activities that will occur. Any ATS should have this comprehensive plan.

Formative Evaluation

The approach to formative evaluation in this program is unique, that is, we divided formative evaluation into subordinate plans. There are formative evaluation subordinate test plans for ISD and the TMS. The Training System Support Center (TSSC) is a real service-oriented kind of test situation. It tests the contents in your CLS. We have also started getting into configuration kinds of issues in most tests, and the main thing is operation of the Configuration Working Group (CWG). When you start getting into the day-to-day operations, how do you pass the paper along? What kind of maintenance are you going to do to keep your people current? It should all be tested in formative evaluation. This applies to the point I made earlier about guaranteeing the "factory."

System integration testing has been a big problem for us in formative evaluation. In fact, it has probably slipped over into summative by default. We fought very, very hard to get them to test the TMS to some level for integration during SGTOs. In the first three blocks, the TMS was not ready. In retrospect, the government should have said, "Sorry contractor, you don't run your SGTO until the TMS is operating." What happened was that the TMS was a separate contract line item, so the software folks were operating on a schedule to meet that requirement alone. They were not operating under a network umbrella to ensure that the TMS along with the courseware, instructors, and facilities all came together at SGTOs. So systems integration was a problem for us; it still is. We are picking up the ball and running with it in the early classes of summative and we are getting it done. But it is costing the contractor more dollars.

Summative Evaluation

The two key contractor people responsible for the summative evaluation phase previously worked on the C-5 ATS T&E program. As a consequence, they were able to apply all of their lessons learned and experience to this program. They never had a quality T&E report out of the C-5; the approach and procedures they have developed for this program have produced a tremendous document. In fact, it covers everything from student critiques, to scheduling, TMS support, instructor critiques, supervisor evaluations, you name it. For instance, we are obtaining detailed course critique data from about 20% of the students going through the courses. That is, we use 20% of the throughput from each group of students going through a course, and we are critiquing all of the lessons in each course.

Operational Evaluation

The operational evaluation plan is not due until 30 days before TSRR. Although I have not seen a draft because it is too early, I feel it will be a good plan. I hope to take the best of the summative evaluation, the best lessons learned, and also the best information out of the Management Indicators report and continue those procedures for the life of the program. I think that is a sound approach.

A final comment about T&E. When I talked to the SOF ATS contractors, it was obvious that T&E to them is hardware. So they are talking DT&E (Development Test and Evaluation), OT&E, 48-hour requirement on software and that sort of thing, and the bigger issues that are going to sink the ship at the program level do not even cross their minds.

Quality Assurance

Quality assurance (QA) is one of my biggest lessons learned and one of the things I am proudest of. In my view, it is second in importance only to T&E. In trying to get a handle on this area during source selection, I found out that the manufacturing people at ASD did not want any part of it, AFOTEC (Air Force Operational Test and Evaluation Center) did not want any part of it either, nor did the test people at Headquarters MAC. Therefore, it was left to us to handle the "quality" and T&E functions. We built that part of the program from the ground up. It is a unique philosophy, but I will say that we have done it in close coordination with AFCMC (Air Force Contract Maintenance Center) and received their guidance to make sure we are in accordance with Air Force regulations, particularly AFR 74-15 (Procurement Quality Assurance), which is the government QA bible.

The major difficulty for us was overcoming the hardware orientation of the traditional QA program. The acquisition community is set up to handle hardware. In fact, this was the first contract to come out of ASD that had a clause for a "services oriented" QA. When ASD found out about that, they wanted to take it out because they did not know how to manage it. What has really paid dividends for us is having two full-time GS-12 QARs (Quality Assurance Representatives) and one major who had the capability to build a QA program from the ground up that covers all aspects of the ATS. It covers training operations, courseware, TMS, TSSC, and all those areas that have not been a part of the traditional hardware/software QA programs.

Contractor Quality Assurance (QA)

Quality assurance for the contractor is basically just ensuring that he is complying with his own policies, procedures, processes, and plans in a best-commercial-practice manner in a situation where you are allowing him to bring his innovative skills to the table. In some cases we care, but in most cases we do not care how he runs his program. What we do care about, though, is our desire to maintain the factory guarantee at some sort of a standard, and that standard is whatever the contractor defines as the standard. What we have found in our investigation of other ATSs is that if you do not monitor the program (particularly after contract award), the standard tends to drift down and the tendency is to lean out, lean out, and lean out to increase the profit margin. So you need some way, acceptable to both sides, to ensure that what you bought is what you maintain so that the government is positioned for recompetition should it become necessary. By the way, except for the two new ones--C-141 and C-17--there is not an ATS out there that still has the same contractor who won the original award. They have all been sold off or, like the E-6, have been terminated and recompeted. You have to plan for recompetition to protect the government. Either that or you have a factory that

nobody wants to take over without a large amount of additional funding. In some cases, you may have to recompete without much prior warning when a contractor decides that he wants to get out of the military training business.

Another important point that I want to make about QA is that it is an external function; that is, it has to be independent of the areas that it is monitoring. It should be external for both the contractor and the government. One of our problems early on was that the contractor always wanted their QA people to work internally within the divisions. We ran into some big problems because when they would find they were not in compliance, their own managers would not let them write it up, and it just cannot work that way. This approach to me is QC, not QA. We finally reworked that issue, and they now have an independent QA staff of four full-time people--a QA manager running it, a software person, a courseware person, and a maintenance/logistics person. Right now they probably need another person to handle the training operations side, since most of our current problems involve the integration between the flight line and the contractor. These include such things as signing off check rides and remediation issues that do not really fall into those other three areas.

The big problem for contractors in QA is that they will have a QA policy for hardware and software, but not for ATSs. I have been around talking to other vendors such as Hughes, McDonnell Douglas, Logicon, and General Electric, and none of them have QA policies and procedures specifically designed for training systems. QA policy is generated at the corporate level as in TQM (Total Quality Management) which emanates from that corporate level president. You can call Link in Binghamton, NY, and find someone who works for the company president who is in charge of QA, but the first thing he tells you is, "I only do hardware." If you ask, "Who does courseware?" or, "Who does your instructor hiring and maintenance to make sure they maintain their skills?" or, "Who's responsible for the TMS and TMS software and TMS data?" and there are no answers.

The first thing we had to do was go back--and it took months to do this--get a policy written and then get the president to sign off on it. Once there was a policy, the next step was for each division to write a division level manual to implement that policy. Neither of those documents are specific to the C-130. They are for ATSs in general, but they are systematic. After each division has its manual, the contractor QA staff can write the QAPP (Quality Assurance Program Plan) which is usually a contractual deliverable. Of course, the local group may write a plan and say, "Here's how." Then the division will say, "No, that's not how we want to manage that." So they will have to go back to be compliant with the management procedures--who reports to whom, or whatever.

QDIs (Quality Departmental Instructions) are what make up most of the QAPP. There are some general statements about how you are going to build it and what it is going to cover; then you get down to the QDIs, which are actually just checklists. You should have a checklist for just about every procedure, every process, every plan, everything that you are doing. QDI is an external checklist that the Quality Assurance Department uses for their random checks (approximately 5%) every six months.

QDIs are based on DWIs (Departmental Work Instructions). What does that mean? For example, in the formative evaluation ISD subordinate test plan, they explain in great detail these 55 steps for developing a lesson. For each step they say, "Our department will do this, QC will do this, and Instructional Development (ID) will do this on each lesson." They also explain for each group that when they review the lesson process, they will look for this... and so on. Those are the work instructions, and this is how they are going to develop lessons. If we accomplish all of the 55 steps, then I feel comfortable that when a lesson comes out at the end, after all of the T&E and government checks, it will be a good lesson.

A couple of little problems we have had that make good lessons learned follow.

Let us say you do not like your 55 steps, you want to make it 49 because you have learned some things and are a little more efficient. For instance, you do not need the art department to review simulator instructor guides, since there is no art work. So it makes sense to cut that step out. However, if you do not tell your quality people, both in the government and in your own company, you are changing the procedure, then when they come over to do an inspection, they do not care that there is no artwork. It makes sense for the lesson not to go to art, but your procedure says it has to go to art. You get a write-up because you are not following your own procedure. We have had to teach them that it is fine to change it, we want you to change it, we want you to be more efficient, we want you to make a profit, but change it through the approval cycle. First, get the change approved and <u>then</u> implement it. Do not just implement it willy-nilly, and most of our QDRs were just that. There were better ideas, but they were not following proper channels for changing procedures.

Changes in procedures have to be controlled. Everybody cannot do what he thinks is best without formal coordination. There are a lot of problems between sites in that regard with respect to such things as the maintenance support plan, logistics support plan, and so on. Each site manager could say, "Oh no, I don't like that. Here's how I'm going to do it." Well, our guys would go out and do a QA visit and say, "Hey, you're not in compliance with the plan." "Oh I know. I got a better idea." Wrong, sorry! Get them to change it at the program level. Because we want an audit trail, we

want a factory out there that is standardized, so that we can sell it to another contractor if required.

Government QA

Despite the fact that QA is really a contractor responsibility, you must have on-site government surveillance to ensure that it gets done properly. Although both the C-17 program and the C-141 program have been in being for some time, there is still no on-site contractor QA. I understand they are trying to do QA for the C-17 out of Long Beach, CA. They recognize now they cannot do that and are trying to hire somebody to put on that position at Norman, OK. The key here is to require external QA personnel working for program management at the individual program level as well as corporate.

You cannot write the government QA plan until you have the QDIs from the contractor's QAPP. We use Formtool with two side-by-side windows. On one side is the QDI checklist and the other side is what we will check to verify a QDI checklist. Primarily, what we do is look at their quality reports to make sure that they do what they said they were going to do. If they say they are going out every three months to look at something, are they actually going out to look at it and what do their reports reflect? Also, are they doing follow-ups? If we go out and do our checks, we exclusively use their checklists so there are no surprises. The other nice thing about QA is that not only are there no surprises, but most of the issues that come up we try to solve at a low level. If it does not get solved at the worker level, I throw it in the QA arena and have their QA and my QA get in the books, get in the proposal, get into the plans and make a decision. In almost all cases, they work it out. If they agree, then we do not write a QDR, Method B or anything. We give them time to work it, and if at some point they are not in compliance and they say, "Yes, we know it, but we're not going to do anything about it," that is when we formally write them up. We give them every opportunity to fix it, and that kind of relationship has really made QA work very well.

QA is not a black-and-white issue in an ATS as it is for hardware and software. You cannot put calipers on students and you do not hook an oscilloscope to their heads to measure what they have learned. After all of our formative and summative evaluation, you have to build a program that is operationally feasible--and it works. So that is what we are "QA-ing" against. You work out the differences on the plans.

Another area in QA is ATD training. Simcert (the Air Force simulator certification group) is a big part of it; they are involved in QA with us on the hardware and the fidelity checks. CLS is also a big part of it. Of course, the bottom line is that not only are we training and have devices to support the training and are getting that guaranteed student against all of those

objectives, but we are involved in QA--and this is probably the biggest part--we QA to ensure quality and to make sure we have a viable recompetition package.

Let me give you an example. One year into the program I asked, "Is every item officially tagged that we (the Air Force) bought under contract for this program? Or when they finish development, are they going to haul a bunch of our equipment/furniture away?" We called the C-5 guys to see how they identified all of their equipment. We called them because they were two years ahead of us, and they said, "Oh, you know we haven't tagged anything either." So, we went into a big effort with an inventory sheet to tag and put stickers on all the items the government bought. That is all the items that stay if the contractor should ever leave. The contractor also purchased some additional items on their own. This whole issue is very important to consider for recompetition, the furniture, typewriters, etc., that we purchased have to stay. If they take all of the copy machines and all of the computers, the next contractor that comes in has nothing to work with, and it is going to be expensive for the government.

Configuration Management

Configuration management includes the standard hardware and software functions which have been done for years and are pretty cut and dried. When you ask for "best commercial practice," the contractors all tend to follow AFR 57-4 (Modification, Approval and Management), because that is what they have all used in the past. The hardware arena has not been a problem on this program and probably will never be a problem except for the integration with the rest of the system. The TMS software, however, is another matter. There is no set standard established for computer software, and there are many for "best commercial practices." Our contractor chose to use DOD-STD-2167 (Defense System Software Development), but we had to tailor it drastically to fit our needs. It has traditionally been used to write software for simulators. We downgraded the requirements to six DIDs (Data Item Descriptions) that described such things as the software test procedures, software test reports, etc. I cannot remember the others, but there were six DIDs used, and it has worked very well for us. It is very important to have a standard of some kind so that it will be configured and baselined so that we could QA it in accordance with "something." Since the TMS itself was being developed in Dallas, TX, we tasked DCAS (Defense Contract Administration Services) in Fort Worth to QA the TMS programming development. They had no idea what was going on, had never done this type of oversight before, and we have not received very much input from them. This could lead to some problems down the line.

Courseware

Courseware is a new and very complex issue for the acquisition community. My view of this is that a contractor probably needs to bring at least one good expert onboard very early to set up the development program. You really do not get involved in this until those first lessons start reaching the last five or six steps in the 55-step process. But once that happens, the volume is awesome. The contractor has fifteen full-time people working changes, and if you walk across the street, there are mounds of documents. I think the last I saw there were 350 DRs open that they were trying to accomplish with fifteen people. It is a very labor-intensive thing, but it is a unique process. I must note that in the courseware area, it is not only the courseware lessons. Included are the task listings, student orientation manuals, and course summary documents. All of these must be kept current with changes to the lesson; you cannot concentrate on the lesson only. Because of the continuing volume on a program this big, you will never catch up if you get behind on the supporting ISD documents.

TMS Data Configuration

Interposed between the TMS software and the courseware is the TMS data. The issue here is who owns the data, and how do you configure it? In the courseware area, there are always many changes to test questions, e.g., rewriting bad questions and rephrasing the questions for foreign students, etc. This usually generates changes to the TMS database, such as the grading procedure in the performance measurement module which must be kept concurrent. We became aware of the need for configuration management of this area when we would change a test and hand it out to the student. The student would take the test and get an answer right, but the TMS would mark him wrong. We would remediate and he would say, "Wait, I got that right," and upon checking, we found out that he did get it right.

Integrated Configuration

The integrated configuration area is very difficult conceptually. For instance, you have to implement the software changes and data changes at the same time that the instructor hands out the new courseware, and that is very important. I will give you a good example: When I sat on the configuration working group, and someone brought up a subject for consideration, the first thing I would ask myself is, "Does this DR (Deficiency Report) affect anything else in the system?" If you do not think like that, you will get noncurrent real quick.

For example, we had a TO (technical order) change that changed the location of the lights on drop zones for night drops. A DR was written to change the visual system, which was approved. Then I started thinking and said, "Hey, is there any academic courseware

that tells the navigators or anyone else what to look for prior to the simulator lesson?" ISD said, "Yes, that's in a lesson." I then asked, "Do you think we ought to write a DR for the academic lesson too?" This approach prevents students saying, "That's not what they taught me in academics." We did more research and found out there was a test question for the navigators that covered where the lights are located for night drops. We had to go back to change the test question which was in the TMS data base. We ended up with three DRs on one subject at the same time.

In an ATS environment, you simply cannot follow the traditional hardware/software configuration approach. For example, you cannot simply write DRs to take care of simulators, because they impact other parts of the system, particularly the TMS and courseware. We have refined and integrated the process, and it works very smoothly. During the assessment of a DR, we actually have boxes that we check off that say, "Does this affect the TMS? Does this affect the lesson specification? Does it affect the MSSR?" If it does, you attach the appropriate sheet, and then it is logged into the configuration module. It does not get the final signoff unless all of the other areas are completed and signed off also. This is a very important concept in an ATS, and that is why it takes fifteen people. It is not just looking at a lesson that has a few sentences changed; it is the assessment and checking to see what else it affects across the system.

Configuration Working Group

The Configuration Working Group (CWG) is where it all gets managed. The usual trigger is a write-up emanating from the T&E process, except for a formal modification to simulator hardware or software. For example, any courseware write-up or any TMS write-up would start out as an ICP (instructional change proposal) in the T&E arena. However, we are not limited to courseware only, it can be on anything in the system. The flight line instructors or anyone else who sees anything can submit a write-up. The write-up goes through an analysis stage and is given a number. It comes down to my folks for review and when both sides agree that it is valid, it is submitted to the CWG and turned into a DR. The CWG prioritizes the DRs as critical, significant, or routine. The preponderance of what we have, the important ones, are usually categorized as significant. We have not had any criticals. The criticals are safety-of-flight and have to be implemented within 24 hours.

We have had quite a few significants--350, I think--that we have been running for the last couple of months and a lot more routines. Routines are quarterly updates, typos, references, and items like that. The members of the working group for the government include government QA people. That is to make sure the proper process is followed. When we close out each DR, the final

step is QA's stamp that certifies, "We've gone through all of the hoops and closed it out as an official change to the baseline."

Simcert also sits in on the CWG. They are our experts on what is going into the simulator, and they are in the best position to judge whether or not suggested simulator changes are valid, nice to have, or hokey. This oversight is important to keep costs down. I, myself, have been representing operations. But if we have a lot of DRs for navigators, for example, I will take a navigator along or whatever other kind of expertise is required by the agenda. The contractor also will bring in their experts to discuss items when necessary. For the most part, I do not question the individual items since the write-ups have been reviewed and proofed by the government SMEs as ICPs. When I do question something, it is usually on the potential impact relative to other parts of the system.

The contractor's configuration manager runs the CWG meeting and has the final say on priorities and so forth because it is their system. We can still disagree and the next step is the SRB (System Review Board) which is run out of HQ MAC/DOT. Generally, however, it has not been a problem coming to an agreement. The first meeting we ran went four hours. We had a lot of non-essential people at the meeting, and they were fighting among themselves. To correct this, we decided to build the agendas ahead of time and get them out the day before.

Lessons Learned

At this point, I will attempt to summarize the major lessons learned from my experiences in this program. Some of these lessons tie into things we have already talked about. However, there is another major area which I have not covered, but should be a major consideration in all ATS programs. It is the need to ensure that the system is designed to interface and function effectively within the context of all the relevant government regulations, communication channels, etc., that are a part of the program's operating environment within the military.

Spend Time on RFP

When the contractor gets ready to develop and implement an ATS, every sentence in the RFP (Request for Proposal) is looked at with a microscope. In the C-130 we probably spent more time than any other ATS program fighting hard for operational issues. Even that in my view was not enough. If I had it to do over, there are some areas that I would ensure that more consideration be given to operational issues which cannot be well defined in a statement of work. We recognize that the contractor wants as much specificity as possible so he knows what he is bidding on. However, there are many times you do not really find out what it takes to develop and field an ATS until you are at an operational site and become

familiar with the operational requirements and constraints. Much of the precontractual work is done in a relative vacuum in this area.

Check CLINS Against the Winning Proposal

You should do a thorough postaward audit to ensure that the contractor's proposal satisfies the real requirements of all of your contract line items (CLINS). There are a number of areas where we had problems because we missed some important disconnects between the proposal and real-world requirements. One of the crucial ones was the TMS. It was out there all by itself and not required contractually to come on line with the courses. These two requirements should have been tied together. Another one was that our SOW (Statement of Work) had one CRR at the end of 28 months, and the contractor elected to do it in nine separate blocks, which was a lot smarter. However, if they did not make their milestones, we could not do anything to them for changing them around because there is no penalty, there are no incentives, there is nothing there because we never changed the contract to match the nine projected CRRs. I would recommend that as soon as you pick a winner, use the postaward conference to go back through the contract and look at what is in there. Make sure that there is a proper match and identify some incentives and some penalties tied to the contractor's performance.

Require a Detailed Network Schedule

A detailed network schedule is critical, especially for the acquisition agency. In my view, we never had one for the C-130 except, perhaps, for the SCNS modification. We reworked the schedules again and again trying to get all of the program elements integrated. We started with a set of relatively independent schedules. For instance, the TMS folks built their development schedule in Dallas, the courseware folks built theirs, the people that were hiring the instructors had theirs, and there was another for facilities. We were down to the wire getting electricity and air conditioning in to run in the computer rooms in time for the first courses. As I stated before, we had to run three SGTOs with no TMS because nobody had looked at the bigger picture. We were delivering lessons to SGTOs one day before they were taught. Nobody had thought about the fact that the instructors needed time to study before they met their students. The need to develop network schedules during early planning is critical to guarantee that everything comes together when needed. You also have to integrate your testing. When do these test points fall out so that you know the course has a chance of working when it is networked together?

Start T&E and QA Early On

You need your initial T&E and QA cadres on-line from the beginning because they have to start working on the timing, integration, plans, policies, procedures, processes, to, if nothing else, get that overall big umbrella. It starts with a corporate policy that supports the program. You have to build a master test plan before you can build one for each of the divisions. You have to define your goals and objectives, identify the working relationships, etc., and then you can develop the detailed procedures.

Define Goals (CRR, TSRR Requirements)

With respect to procedures, CRRs were very easy for us. We had a 28-page checklist, and there were no surprises. If you accomplished everything on that checklist, then a government review was a nonevent. If there was an action item, everybody knew it was an action item before the meeting. As long as they had an agreed-upon date to have the action item cleaned up, CRRs were no problem. The same thing for TSRR. We have just finished a quarterly Management Indicator report that displays all of the relevant system trends. If we are within the goal limits and all issues are cleaned up, along with all of the ICPs and DRs, it will be a nonevent. We have identified and agreed upon the goals and objectives one year before they are due. There should not be any discussion at the last minute about what we thought should happen versus what did happen, and it really should be easy. Although what we are doing is listed as basic principles in all of the management textbooks, it is not implemented in some of the other ATS programs and was difficult on this one.

Take Advantage of the Current System

Contractors should take advantage of what is already available in existing systems before starting to build a new one from scratch. We probably could have saved a lot of time and many, many man years of effort if the contractor had just looked at our existing program and used it as a point of departure. MAC has been training C-130 aircrews for thirty years, so there is a lot of wisdom and experience that has been incorporated into the system. The contractor could have gotten a leg up on a number of issues involving such things as aircraft generation, instructor requirements, facility limitations, etc., by taking advantage of information already in existence. In my view, they could have saved a tremendous amount of time and effort had they done that, but they wanted to do it all new from the beginning. That was their choice. However, they ended up going back and using a lot of what we have today, particularly in the tactical area, because it is so complex and because of certain limitations on aircraft generation capability. In many cases, there probably is not a

significantly better way to do some of the things being done in the old system or it would have been done previously.

Real-World Requirements

When a conflict occurs over real-world requirements, they have to take precedence over the SOW and the specification. If you have to change the contract to meet these requirements, then you change it. A good example is the concept of integrating aircraft sorties with the ground training portions of a course. This concept initially would have produced a ten-aircraft generation requirement surge one day a week. I went down to the DCM's (Deputy Commander for Maintenance) shop to discuss it, and he laughed as he was throwing me out of his office. He said, "Dream on. I can't generate airplanes like that." There is nothing in the RFP or SOW that says the contractor has to talk to the DCM to see what he can generate, but you still cannot build these requirements in a vacuum. They have to be implemented in the real world. These real-world requirements are a fact of life and you usually don't even think of them until you are actually involved in building the system. If you tried to specify all of the real-world requirements and the regulation interfaces that are required, your RFP would have to be carried in a wheelbarrow. But, those are the things that the acquisition agencies and the contractors need to understand. You cannot anticipate everything and put it in the RFP and SOW, so you have to have work around and be flexible enough to deal with the real-world constraints.

Schedule Versus Quality

It really made me feel good when ASD came down and said, "Schedule vs. quality is not an issue; we must always have quality." It has made my job a lot easier knowing that I have that support. We have had a lot of schedule perturbations because of underscoping and so forth, but whenever it came to quality we slipped the schedule. As long as we had the manning to keep going under current courses, which we have, it has not been a real problem for us. We have had to study it closely, but it is something we have been able to live with. In my view, slipping this program for four months to get the quality that we needed is not even close to the issue of having to live with a program that does not work and trying to fix it for the next 20 years. So, while we are in acquisition, let's do it right. If you meet the schedule, that's great, but if you do not, when the two butt heads, the schedule has to lose; it has to lose if it means sacrificing quality.

Integration! Integration! Integration!

Remember that when you go out to buy a house, the three most important considerations are: location, location, location. On the other hand, when managing the development of an ATS, the three

most important considerations are: integration, integration, integration. Even at the level of writing a lesson, if a flight engineer is developing a simulator lesson, he must go over and integrate that lesson with the pilots. Because the flight engineers cannot do their thing in the simulator independent of what the pilots are doing, the lessons have to be integrated. Thus, you have to integrate at the lesson level. You also have to integrate at the unit level and at the course level. You also have to integrate across courses and crew positions. It just keeps growing. You have to integrate ISD products with the TMS capabilities to be sure that they will work together, and it goes on and on.

My primary job when someone brings me a problem is to scope it and determine the ramifications for other parts of the system. For example, if someone identifies a problem with the TMS, my concern is with what is the impact on courseware? What is the impact on the instructors? What does it do to simulators? What does it do to the schedule? You have to think system-wide every time you face a problem. And if you don't, you fix one problem and it looks great for this part of the system, but it may have a negative impact on another part of the system and may have to be redone again.

Integration is the key. When the contractor brought in their two integration managers, they brought a lot to the game. They helped accomplish the required integration, particularly between TMS and ISD. Integration is what makes it work in the real world. You have to manage it very closely or they will lose their shirts in terms of dollars, and we will lose ours in terms of quality. Having someone on the contractor's team and the government's team who has seen it before and can avoid the major pitfalls is extremely important, and vital to success.

III. CONCLUDING REMARKS

As noted in the Introduction, it is believed that the information presented in this paper can be a very useful source of guidance for both acquisition and using agencies involved in the development, implementation and/or utilization of aircrew training systems. The information provided by Lt Col Dukes is particularly credible, because it is based on the actual experience gained from his deep personal involvement in the C-130 ATS program from conception to implementation. As a consequence, at the time of this interview, he was in a position to assess the validity of some of the early design and development assumptions as well as to provide an Air Force user's perspective concerning what was really required to make the program work.

The authors recognize that the specific requirements of particular ATSs may differ because of differences in the size,

scope and/or complexity of the programs. In addition, programs for new systems such as the C-17 and ATF do not have access to much of the historical training and operational experience that is available to existing systems, such as the C-130, C-141, and C-5. Thus, there is probably always a need for "tailoring" in certain areas to meet the unique requirements of any given program. Despite these differences, the authors believe that much of the information provided is sufficiently general to warrant consideration by most of the new and existing programs with which they are familiar. The authors have included both a set of references cited in this paper as well as a separate bibliography of additional publications which may be of interest to any reader desiring more information in this area.

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GLOSSARY OF ACRONYMS

AFCMC	Air Force Contract Maintenance Center
AFORMS	Air Force Operations Resources Management System
AFOTEC	Air Force Operational Test and Evaluation Center
ASD	Aeronautical System Division
ATD	Aircrew Training Device
ATS	Aircrew Training System
AWM	Awaiting Maintenance
CASS	Computer-Assisted Squadron Scheduling
CBT	Computer-Based Training
CCA	Course Configuration Audit
CDR	Critical Design Review
CIQ	Copilot Initial Qualification
CLIN	Contract Line Item
CLS	Contractor Logistics Support
CMI	Computer-Managed Instruction
CPT	Cockpit Procedure Trainers
CRR	Course Readiness Review
CWG	Configuration Working Group
DCAS	Defense Contract Administration Services
DCM	Deputy Commander for Maintenance
DID	Data Item Description
DO	Deputy Commander for Operations
DOD	Department of Defense
DOO	Operations Center
DOT	Director of Training
DR	Deficiency Report
DT&E	Development Test and Evaluation
DWI	Departmental Work Instruction
ICP	Instructional Change Proposal
ID	Instructional Development
ISD	Instructional Systems Development
ITO	Individual Try-Out
IVD	Interactive Video Disc
MAC	Military Airlift Command
MATS	Model Aircrew Training System
MSSR	Media Selection Syllabus Report
OBE	Overtaken By Events
OT&E	Operational Test and Evaluation
PDR	Preliminary Design Review
PMM	Performance Measurement Module
PTT	Part Task Trainer

QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QAR	Quality Assurance Representative
QC	Quality Control
QDI	Quality Departmental Instruction
QDR	Quality Deficiency Report
RFP	Request for Proposal
SCNS	Self-Contained Navigation System
SGTO	Small Group Try-Out
SIMCERT	Simulator Certification
SME	Subject Matter Expert
SMM	Scheduling Management Module
SNS	Satellite Navigation Station
SOF	Special Operations Forces
SOW	Statement of Work
SRB	System Review Board
T&E	Test and Evaluation
TMS	Training Management System
TO	Technical Order
TQM	Total Quality Management
TSR	Training System Review
TSRR	Training System Readiness Review
TSSC	Training System Support Center
TTTS	Tanker Transport Training System
UTO	Unit Try-Out
WST	Weapon System Trainer